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AUTHOR Brennan, Mervin M.; And Others
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ABSTRACT

Presented is an overview of the 1979 Illinois Inventory of Educational Progress (IIEP) for eighth-grade mathematics. The IIEP is a systematic effort by the Illinois State Board of Education to collect information on the educational achievement of Illinois students in certain areas and to make that information available to educational decision-makers. The IIEP employs an objective-referenced approach, with desired student performance expressed in terms of objectives. Students to be tested are selected in a two-stage random sampling method. Since the IIEP is geared towards determining how groups of Illinois students perform on given tasks, no individual student, teacher, school, or district is identified. As part of the study, teachers of participating students were asked to estimate the percentage of students who would obtain correct answers to individual test items. Of five objectives containing three or more items, teacher estimates were higher than student performance in all cases, but the difference was only statistically significant for one objective. (MP)

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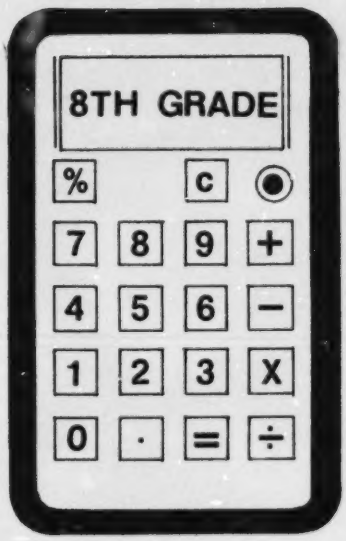

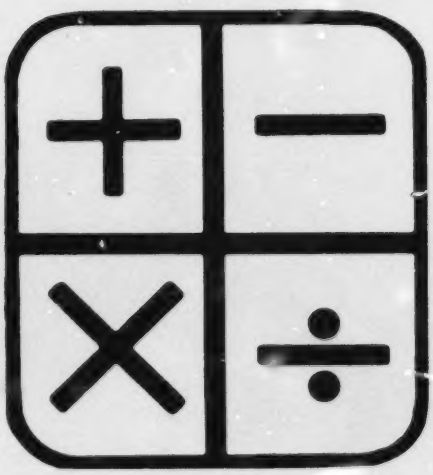

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FOREWORD

What follows is designed to provide an overview of the 1979 Illinois Inventory of Educational Progress (IIEP) in eighth grade mathematics. The test has been administered by the Illinois State Board of Education since 1976; however, this analytical report is in a new and more usable format.

Development of the IIEP is discussed, and results and analyses of the test administered to eighth grade students are presented. Results and analyses of fourth and eleventh grade tests can be found in separate reports. It is hoped that the information contained here will enhance instruction in Illinois schools.

While many state staff members contributed to the preparation of this report, I would like to especially acknowledge the efforts of Dr. Mervin M. Brennan as the main writer. Any questions concerning this report may be addressed to Dr. Brennan or Dr. Thomas Kerins, Manager of the Program Evaluation and Assessment Section of the Department of Planning, Research and Evaluation of the Illinois State Board of Education.

Donald G. Gill
State Superintendent of Education

PREFACE

Purpose

The Illinois Inventory of Educational Progress (IIEP) is a systematic effort by the Illinois State Board of Education to collect information on the educational achievement of Illinois students in certain areas and to make that information available to educational decision makers.

The three goals of the IIEP are:

1) to make available relevant, reliable, and valid data on the educational attainments of Illinois students;

2) to identify any trends (growth, stability, or decline) in educational attainments which occur over time; and

3) to publish results of the research conducted in connection with the IIEP.

Student Selection

A random sample with two sampling stages is used to select those students attending Illinois public schools who will participate.

First, schools throughout the state are chosen randomly. A sample of fourth, eighth, and eleventh graders is then randomly selected from lists of eligible students submitted by schools for participation. These grade levels are selected to correspond roughly with the end of the primary, elementary, and secondary levels of education.

Since the IIEP is geared toward determining how groups of Illinois students perform on given tasks, no individual student, teacher, school, or district is identified in any reports of the results.

Type of Test

The IIEP employs an objective-referenced approach. An objective-referenced assessment instrument assesses student performance. Desired student performance is expressed in terms of objectives. An objective is a statement of desired student performance, for example: "Fourth grade students should be able to recognize geometric shapes such as circles, etc." Student performance is measured by test items designed to determine whether or not certain groups of students are able to do what the objectives state they should be able to do.

Subject Areas

The IIEP has been in existence since 1976. A number of subject areas have been assessed, for example, reading, mathematics, science, citizenship, energy and nutrition, as well as student attitudes about themselves and education in general.

Base line data is collected during the first year that any subject area is assessed. For each succeeding year that a subject area is reassessed, comparisons can be made concerning student performance on specific objectives, and any growth or decline in achievement can be noted.

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CHAPTER 1

Illinois Inventory of Educational Progress - Mathematics

Development of the 1979 Mathematics IIEP

In the spring of 1978, a panel of six mathematics educators with elementary, junior high, high school and college teaching and administrative experience was convened to assist State Board staff in formulating the 1979 mathematics IIEP (a roster of panel members appears in Appendix D). Charged with redrafting the objectives which had been developed for the 1976 IIEP, the group met over a two-month period. The results of their work are discussed later in this report.

Additionally, results of a teacher survey that was administered with the previous year's IIEP (1978) were used in developing the 1979 mathematics IIEP. Produced by State Board staff, the survey sought to: (1) validate the test; (2) supply an additional perspective on the results; and (3) provide a standard of performance, based upon teacher estimates, with which student results could be compared.

Toward that end, one mathematics teacher from each school which participated in the IIEP was asked to do three things for each test item. Teachers were asked to determine (1) whether students had been exposed to the material and (2) whether the item was of an appropriate level of difficulty. Teachers were also asked (3) to estimate the percentage of students that could be expected to answer each item correctly. A sample of the teacher survey is contained in Appendix C. Results of the teacher survey are discussed in Chapter 2.

The Test

The test was a domain and objective-referenced test, which means simply that the items tested the general domain of mathematics and that items are derived from or keyed to a set of curricular objectives.

Mathematics objectives for the 1979 IIEP were developed by the aforementioned panel of educators. The following mathematics topics and abilities reflect those objectives. A list of topics precedes a summary description of abilities. Some of the topics are self-explanatory; a brief definition is provided for those which are less common. The abilities are a bit more detailed; essentially, they are the skills required for success in mathematics. Each mathematics objective describes a particular ability with reference to a specific topic.

Mathematics Topics

I. NUMERATION CONCEPTS. This topic refers to the concepts of numeration and place value, and the processes of naming numerals, approximating numbers, and rounding off numbers.

II. PROPERTIES OF NUMBERS AND OPERATIONS. This topic also includes characteristics of numbers and operations and comparisons among numbers.

III. NUMBERS.

A. WHOLE NUMBERS. Whole numbers are the numbers used by children to count. Whole numbers include 0, 1, 2, 3, etc.

B. FRACTIONS.

C. DECIMALS.

D. PERCENT.

E. INTEGERS. Integers are positive and negative whole numbers and zero as distinguished from fractions. The numbers -3, -2, -1, 0, +1, +2, +3, etc., are integers.

F. RATIONALS. Rationals is an all-inclusive term for topics A through E, both positive and negative. Examples are +2, +1/2, +.50, +50%, -2, -1/2, -.50, and -50%.

G. REALS. Reals is an all-inclusive term for topics A through F and numbers such as π, $\sqrt{2}$, etc.

IV. MEASUREMENT.

V. ALGEBRA.

VI. GEOMETRY.

VII. PROBABILITY AND STATISTICS.

VIII. PERSONAL AND CONSUMER MATHEMATICS.

Mathematics Abilities

1. Ability to recall and recognize facts, definitions, and symbols quickly. Perception is the primary mental act used.

2. Ability to perform computations, procedures, and complex counting where the operations are indicated.

3. Ability to understand concepts, facts, and processes. The mental operations of analysis and synthesis are used to make comparisons and evaluative judgments.

4. Ability to solve complex word problems. Several of the following operations must be involved: interpretation of the question, identification of the relevant data from the given information, decisions about which operations need to be performed on the data, correct performance on the operations, and interpretations of the results.

Each mathematics item tested a student ability with respect to one of the mathematics topics. The matrix of mathematics topics and abilities (Table 1) shows the conceptual model of the IIEP mathematics tests. Each cell of the matrix is a specific mathematics objective.

The test contained items on seven topics and four abilities. There were items related to 19 objectives within the topics and abilities. A topic, ability, or objective was considered to be measured if there were three or more items testing it. By that standard, the test measured five topics and three abilities, and five objectives within them. The test is described more fully in subsequent chapters of this report.

Table 1
MATRIX OF MATHEMATICS OBJECTIVES

MATHEMATICS CATEGORIES BY ABILITIES

Mathematics Topics	Mathematics Abilities 1		2		3		4	
	Ability to recall and recognize facts, definitions, and symbols quickly		Ability to perform computations, procedures, and complex counting where the operations are indicated		Ability to understand concepts, facts, and processes		Ability to solve complex word problems	
I. NUMERATION CONCEPTS	1	*4	2		3	8	4	
II. PROPERTIES OF NUMBERS AND OPERATIONS	5	4, 8	6	8	7	4	8	8
III. NUMBERS								
A. WHOLE NUMBERS	9	4	10	4, 8, 11	11	8	12	4
B. FRACTIONS	13	8	14	11	15	11	16	
C. DECIMALS	17		18	8	19		20	
D. PERCENT	21		22	8	23		24	
E. INTEGERS	25		26	4, 8	27		28	8, 11
F. RATIONALS	29	8	30	11	31	11	32	8, 11
G. REALS	33		34		35		36	
IV. MEASUREMENT	37	4, 8 11	38	8, 11	39	8	40	4, 8 11
V. ALGEBRA	41		42	8, 11	43		44	
VI. GEOMETRY	45	8	46		47	8, 11	48	11
VII. PROBABILITY AND STATISTICS	49		50	11	51		52	
VIII. PERSONAL AND CONSUMER MATHEMATICS	53	4	54	4, 8	55	4	56	4, 8, 11

* The numerals (4, 8, 11) indicate the grade level(s) at which these items were tested in the 1979 IIEP.

Chapter 2

ITEM RESULTS

As mentioned in Chapter 1, teachers of participating students were asked to estimate the percentage of students who would obtain the correct answers to the items. The hypothesis was that the teacher estimates would be higher than the student scores. Chapter 4 shows the statistical results.

It was anticipated that there would be some discrepancies between teacher estimates and student scores which could not be submitted to statistical tests or would not reach significance levels, but would lend themselves to suggestions for future research. After statistical analysis of the data, experienced Illinois mathematics educators were asked to comment on the results.

The following descriptions were used for discrepancies between teacher estimates and student scores:

- approximating for discrepancies of ten or less percentage points,
- higher than/lower than for discrepancies of 11 to 20 points, and
- considerably higher than/lower than for discrepancies of more than 20 points.

These discrepancy guidelines were established because consultants suggested the use of consistent standards. Ten percentage points was used since standard deviations for previously calculated data were usually near .10.

The panel of mathematics educators was asked to analyze and interpret the test results using the test data and the teacher survey data. They reflected upon the data for each curricular topic and each objective within the topics. This chapter gives the data and the panel's comments. Correct answers are underlined. Teacher estimates are abbreviated as teach. est., student scores are abbreviated as stu. score.

The comments are solely those of the experts and are not to be taken as the official position of the State Superintendent of Education or the Illinois State Board of Education.

Topic I: Numeration Concepts

The test contained one item on Numeration Concepts Table 2 shows the results.

Table 2

Objective 3: Understanding Numeration Concepts

Item 61. The length of a box was measured and found to be nine centimeters to the nearest centimeter. Which of these could have been the length of the box measured more accurately?

a. 10 cm.
b. 9.9 cm.
c. 9.62 cm.
d. 9.6 cm.
e. 8.6 cm.

teach. est.: 50%
stu. score: 44%

Panel comments: Item 61 was the only test item related to numeration concepts. It required students to relate a rounded measurement to a possible rule measurement.

Fifty percent (50%) of the teachers surveyed noted that their students had little or no exposure to this type of item. A correct response required that the students imagine measuring the length of an object and understand the concepts of estimation and rounding. The teachers estimated that the item would be difficult for students, and the student score approximated the teacher estimate.

Topic II: Properties of Numbers and Operations

There were five items on this topic. Scores ranged from 62% to 25%. Table 3 shows the results.

Table 3

Objective 5: Recognition of Facts about Properties of Numbers

Item 34. Which of these numbers is a prime number?

a. 21
b. 22
c. 23
d. 24
e. 25

teach. est.: 67%
stu. score: 62%

Item 35. Which of the following is true?

a. $8 < 7$
b. $1 < 0$
c. $-1 < 0$
d. $-5 > -4$
e. $-7 > 6$

teach. est.: 66%
stu. score: 56%

Item 27. Which number is the SMALLEST?

a. 2.002
b. 0.202
c. 0.22
d. 0.022

teach. est.: 70%
stu. score: 51%

Item 28. In which of these is the order of the numbers from smallest to largest?

a. 30.99, 31.3, 31.29
b. 31.29, 30.99, 31.3
c. 31.29, 31.3, 30.99
d. 31.3, 31.29, 30.99
e. 30.99, 31.29, 31.3

teach. est.: 67%
stu. score: 41%

Objective 6: Computation Regarding Properties of Numbers

Item 31. Which of these fractions is the LARGEST?

a. 2/3
b. 3/4
c. 4/5
d. 5/8
e. 6/10

teach. est.: 66%
stu. score: 25%

Panel comments: Four items measured objective 5. One item related to prime numbers and three items tested student ability to order integers or decimals. As noted in Chapter 4, the student average score for objective 5 (52% correct) was significantly lower than the teacher estimate (68% correct).

Interpretations of the results should take the following into account: commonly used textbooks and tests do not contain questions like IIEP items 27, 28, and 35; those items are more difficult to solve than they appear to be on a first reading; several response choices are close, and visual discrimination may have been a complicating factor.

On items related to the ordering of numbers, the student score was higher for ordering integers than for ordering decimals and fractions. Item 31 related to the ordering of fractions. The student score was considerably lower than the teacher estimate, which suggests that students have difficulty with such items. Interpretations should observe the cautions listed above.

Considerably more data are needed to understand where the students had greater and lesser difficulties. The data gave rise to several questions. Do students understand the value of invisible zeroes after the decimal point? Do they understand the concept of larger and smaller fractions? Do they have the skills necessary to change fractions to a common scale for comparisons?

Topic III: Numbers

This topic includes the subtopics whole numbers, fractions, decimals, percents, and rationals. The subtopics are treated in that order.

Whole Numbers

Three items measured whole numbers. All were computation items. Table 4 shows the results.

Table 4

Objective 10: Computation with Whole Numbers

Item 38. What is the SMALLEST positive number that can be divided by 6, 9, and 12 without a remainder?

a. 18
b. 24
c. 36
d. 72

teach. est.: 69%
stu. score: 73%

Item 25. $3(2+7)=$

a. 6
b. 12
c. 13
d. 23
e. 27

teach. est.: 75%
stu. score: 63%

Item 39. $4^3 =$

a. 12
b. 24
c. 48
d. 64

teach. est.: 63%
stu. score: 55%

Panel comments: The student average score for objective 10 (64% correct) approximated the teacher mean estimate (69% correct).

Seventy-three percent (73%) of the students appear to be able to perform basic multiplication and division skills. A smaller percentage (63%) seem to have learned the mathematical convention of omitting the multiplication sign before parentheses and the rules for order of operations. A lower number (55%) indicated an understanding of the meaning of exponents.

Fractions

The test contained two items on fractions. Table 5 shows the results.

Table 5

Objective 14: Computation with Fractions

Item 33. 1/2 x 1/4 =

a. 1/6		
b. 1/8	teach. est.:	82%
c. 2/6	stu. score:	77%
d. 2/8		

Item 32. 1 2/5 - 1/2 =

a. 2/3		
b. 9/10	teach. est.:	67%
c. 1 1/10	stu. score:	51%
d. 1 1/7		
e. 1 1/3		

Panel comments: Two items are insufficient to measure an objective. However, the fact that the student average score for objective 10 (64% correct) was lower than the teacher mean estimate (75% correct) suggests that a future investigation of fractions should be considered. Item results point to the possibility that while most of the students (77%) had learned the rule for multiplication of fractions, fewer (51%) were able to subtract fractions. It was noted that the subtraction item is considerably more difficult than it appears at first glance. A correct response required several thought processes and some difficult steps, including the troublesome process of regrouping.

Decimals

There were two items on decimals. Table 6 shows the results.

TABLE 6

Objective 18: Computation with Decimals

Item 24. 11.09 - 8.53 =

a. 2.06
b. 2.56
c. 3.06
d. 3.53
e. 3.56

teach. est.: 87%
stu. score: 85%

Item 26. $.004\overline{)24.56}$

In the division above, the correct answer is:

a. .614
b. 6.14
c. 61.4
d. 614
e. 6140

teach. est.: 67%
stu. score: 56%

Panel comments: The student average score for objective 18 (71% correct) approximated the teacher mean estimate (77% correct). Student scores were higher for the subtraction item than for the division item. However, there is some question as to what the item involving division tested. Did it test division or "student ability to place a decimal point correctly, when the division problem involved decimals?"

Percent

The test contained one item on percent. Table 7 shows the results.

Table 7

Objective 22: Computation with Percents

Item 29. 45% of 180 is

a. 45
b. 90
c. 81
d. 180

teach. est.: 62%
stu. score: 55%

Panel comments: For the one item related to objective 22, the student score approximated the teacher estimate. Several cautions about interpretation are in order. One item does not measure an objective. Percent is in the last chapter of the more commonly used textbooks, and experience indicates that many teachers do not emphasize it. Eighteen percent (18%) of the teachers surveyed reported that their students had little or no classroom exposure to percent.

Integers

There were three items on integers. Two items were on computation, and one was on problem solving. Table 8 shows the results.

Table 8

Objective 26: Computation with Integers

Item 37. $-27 \div 3 =$

a. -9		
b. 3	teach. est.:	65%
c. +9	stu. score:	79%
d. -3		

Item 36. $-2 \times 12 =$

a. 24		
b. -24	teach. est.:	67%
c. 14	stu. score:	73%
d. 6		

Objective 28: Problem Solving with Integers

Item 48. The air temperature on the ground is 31 degrees. On top of a nearby mountain the temperature is -7 degrees. How many degrees difference is there between these two temperatures?

a. 24 degrees		
b. 4 3/7 degrees	teach. est.:	62%
c. 31 degrees	stu. score:	51%
d. 38 degrees		

Panel comments: For the two items related to objective 26, the student average score (76% correct) approximated the teacher mean estimate (66% correct). Student performance also approximated the teacher estimate for objective 28. The student scores were higher for the two items related to computation than for the item related to problem solving. Items 36 and 48 were in the 1978 test. The student score was 65% correct in 1978 and 73% correct in 1979 for item 36, 42% correct in 1978 and 51% correct in 1979 for item 48. A variation of item 37 was on the 1978 test. The 1978 item contained two negative numbers ($-27 \div -3$); the 1979 item contained only one negative number ($-27 \div 3$). Forty-four percent (44%) of the students answered the "double negative" item correctly in 1978, while 79% of the students answered the "single negative" item correctly in 1979. Several questions are suggested by these results. Did the students learn one or more rules about integers, but not all of them? Did students understand the concepts of integers? Did a number of students learn the rules for computing with integers, yet remain unable to conceptualize and solve problems posed in story form?

Rational Numbers

The test contained two items on rational numbers. Table 9 shows the results.

Table 9

Objective 29: Recognition of Facts about Rational Numbers

Item 30. 1/5 is equivalent to what percent?

a.	15%	
b.	5%	teach. est. 63%
c.	20%	stu. score: 52%
d.	25%	

Objective 32: Problem Solving with Rational Numbers

Item 44. A map of the state is to be drawn so that one-fourth inch represents five miles. If the real distance between two points in the state is 20 miles, how many inches apart should these two points be on the map?

a.	1/2 inch	
b.	3/4 inch	teach. est.: 58%
c.	1 inch	stu. score: 51%
d.	1 1/4 inch	

Panel comments: Although the student score for the item related to objective 29 was lower than the teacher estimate, caution must be observed. There was only one item, and 14% of the teachers reported little or no classroom exposure for their students to such content. However, 48% of the students did not choose the correct answer, and several questions are suggested by this result. Did students understand the relationships among fractions, decimals, and percents? Did they know the process for changing fractions first to decimals and then to percents? Were the student errors due more to lack of knowledge or to lack of practice?

The student score approximated the teacher estimate for the item related to objective 32. Forty-one percent of the teachers reported little or no classroom exposure to this type of item for their students, and 49% of the students did not answer the item correctly. Since the item was relevant to everyday life, where was the difficulty? Did students have trouble visualizing the problem, setting up the equation, or computing the answer?

Topic IV: Measurement

The test contained nine items on this topic. Four items measured recognition of measurement facts, two items were on computation, and three items tested problem solving. Table 10 shows the results.

Table 10

Objective 37: Recognition of Measurement Facts

Item 62. An angle may be measured in units called

a. centimeters.
b. degrees. — teach. est.: 86%
c. grams. — stu. score: 79%
d. inches.

Item 54. In the United States, we usually buy potatoes by the pound. In Germany, where the metric system is used, people buy potatoes by the

a. meter.
b. liter. — teach. est.: 70%
c. pound. — stu. score: 77%
d. kilogram.

Item 53. In the United States, we usually buy gasoline by the gallon. In France, where the metric system is used, people buy gasoline by the

a. meter.
b. liter. — teach. est.: 70%
c. quart. — stu. score: 76%
d. gram.

Item 55. The number of centimeters in one meter is

a. 1/100.
b. 10. — teach. est.: 70%
c. 100. — stu. score: 59%
d. 1000.

Table 10 (continued)

Objective 38: Computation in Measurement

Item 57. About how long is the paperclip above the metric ruler?

a. 30 mm		
b. 30 cm	teach. est.:	70%
c. 3 m	stu. score:	50%
d. 33 km		

Item 56. 2 meters + 3 millimeters =

a. 2.0003 meters		
b. 2.003 meters	teach. est.:	52%
c. 2.03 meters	stu. score:	39%
d. 2.3 meters		
e. 5 meters		

Objective 40: Problem Solving in Measurement

Item 58. A 15 centimeter piece is cut from a stick one meter long. What is the length of the remaining piece?

a. 85 cm		
b. 115 cm	teach. est.:	64%
c. 985 cm	stu. score:	70%
d. 1015 cm		
e. 9985 cm		

Item 59. A car takes 15 minutes to travel ten kilometers. What is the speed of the car?

a. 30 kilometers per hour		
b. 40 kilometers per hour	teach. est.:	53%
c. 60 kilometers per hour	stu. score:	32%
d. 90 kilometers per hour		
e. 150 kilometers per hour		

Item 65. The measure of the smaller angle formed by the two hands of a clock at 4 o'clock is

a. 30 degrees.
b. 45 degrees.
c. 60 degrees.
d. 90 degrees.
e. 120 degrees.

teach. est.: 49%
stu. score: 32%

Panel comments: As mentioned in chapter two, there was no significant difference between the student average score for objective 37 (73% correct) and the teacher mean estimate (74% correct). There were only two items related to objective 38, and the student average score (44% correct) was lower than the teacher mean estimate (61% correct).

Regarding recognition of basic measurement facts (objective 37), 89% of the teachers reported that their students had been exposed to the material tested. In contrast, 37% of the teachers stated that students had minimal or no classroom exposure to the IIEP items related to objective 38. The results give rise to two major questions. Were the student mistakes mainly due to lack of knowledge of some basic measurement facts, or the lack of skill in converting from one unit to another?

As reported in Chapter 4, the student average score for the items measuring objective 40 (45% correct) was not significantly different from the teacher mean estimate (55% correct). Interpretations of the data should take into account the lack of experience students had with such material. Little or no exposure was reported by 23% of the teachers for item 58, and 43% for items 59 and 65. The results suggest several questions. Were mistakes due mainly to lack of exposure? Was lack of factual knowledge a major factor leading to mistakes? Should students be exposed to this material prior to high school?

Topic V: Algebra

There were two items on this topic. Both were on computation. Table 11 shows the results.

Table 11

Objective 42: Computation in Algebra

Item 40. If x is replaced by 3, then the value of x^2-1 is

a. 8		
b. 11	teach. est.:	50%
c. 5	stu. score:	49%
d. 2		

Item 41. Solve the following equation: $3x-3=12$. x=

a. 15		
b. 5	teach. est.:	53%
c. 3	stu. score:	50%
d. 9		

Panel comments: Interpretations of the results should take several factors into account. There were only two items concerning algebra, and both related to objective 42. The student average score (50% correct) was nearly identical to the teacher mean estimate (52% correct). Thirty-nine percent (39%) of the teachers reported that students had received little or no classroom exposure to the material tested by the items. Both items required knowledge of basic algebraic concepts and more than one step for a correct solution. The use of exponents, algebraic symbols, and general processes for solving equations posed difficulties for the typical 8th grade student.

Topic VI: Geometry

The test contained three items on this topic. Two items were on recognition of geometry facts, and one was on problem solving. Table 12 shows the results.

Table 12

Objective 45: Recognition of Basic Geometry Facts

Item 64. Angle A is what kind of angle?

a. Acute
b. Right
c. Oblique

teach. est.: 76%
stu. score: 64%

Item 63. Which line segment is a diameter of the circle with center N?

a. NP
b. HM
c. EG
d. HK

teach. est.: 76%
stu. score: 63%

Objective 48: Problem Solving in Geometry

Item 66. In a given triangle, the measures of two of the angles are 35 degrees and 75 degrees. The measure of the third angle is:

a. 40 degrees.
b. 55 degrees.
c. 70 degrees.
d. 95 degrees.
e. 110 degrees.

teach. est.: 57%
stu. score: 38%

Panel comments: The student average score for objective 45 (64% correct) was lower than the teacher mean estimate (76% correct). The items tested students on the definitions of right angle and diameter. Ninety-two percent (92%) of the teachers reported that students had been exposed to the material; 80% described the exposure as adequate to heavy. Only one item was related to objective 48, and the student score was lower than the teacher estimate. Interpretation of the data should take into account that the item required knowledge that the sum of the interior angles of a triangle is 180^{o}. Forty-seven percent (47%) of the teachers reported that their students had received little or no classroom exposure to that knowledge.

Topic VII: Probability and Statistics

The test contained no items specifically related to this topic.

Topic VIII: Personal and Consumer Mathematics

There were eleven items on this topic. One item was on computation, and ten items measured problem-solving ability in consumer situations. Tables 13 and 14 show the results.

Table 13

Objective 54: Computation in Consumer Mathematics

Item 23. Add: $3.06
$10.00
$9.14
$5.10

a. $2730
b. $7.20
c. $17.30
d. $27.20
e. $27.30

teach. est.: 92%
stu. score: 76%

Panel comments: On the item related to objective 54 the student score was lower than the teacher estimate. The item seemed straightforward and uncomplicated. However, 13% of the students chose wrong response "a." They apparently added the numerals correctly, saw that the numerals of "a" were correct, and selected it, ignoring the decimal point.

Table 14

Objective 56: Problem Solving in Consumer Mathematics

Item 49. A sports car owner says that the car gets 22 miles per gallon of gasoline. How many miles could the car go on seven gallons of gasoline?

a. 154 miles		
b. 144 miles	teach. est.:	76%
c. 134 miles	stu. score:	86%
d. 124 miles		

Item 45. Ruth has savings of $17.25. She wants to buy the following things: skirt - $9.00, belt - $3.00, book - $2.50, records - $4.98. How much more money does she need before she can buy all of these items? (Do not include sales tax in your answer).

a. $1.73		
b. $2.03	teach. est.:	72%
c. $2.13	stu. score:	81%
d. $2.23		

Item 50. If John drives at an average speed of 50 miles per hour, how many hours will it take him to drive 275 miles?

a. 6 hours		
b. 6 1/2 hours	teach. est.:	69%
c. 5 hours	stu. score:	65%
d. 5 1/2 hours		

Item 46. Television sets are on sale at two stores. One offers a ten percent discount while the other offers 15 percent. What is the difference in the sale price at the two stores of a TV set that is regularly priced at $100?

a. $5		
b. $10	teach. est.:	58%
c. $15	stu. score:	62%
d. $20		

Table 14 (continued)

Item 43. John's parents bought a refrigerator for $375. If they pay $20 per month for two years, how much more than $375 will the refrigerator cost them?

a. $95
b. $105 — teach. est.: 60%
c. $200 — stu. score: 60%
d. $375

Item 47. Mr. Simmons put a wire fence all the way around his rectangular garden. The garden is nine feet long and five feet wide. How many feet of fencing did he use?

a. 20 feet
b. 28 feet — teach. est.: 70%
c. 14 feet — stu. score: 52%
d. 36 feet

Item 42. A discount of 15% was given during a sale. What is the discount on goods valued at $280?

a. $ 15
b. $ 28 — teach. est.: 56%
c. $ 42 — stu. score: 43%
d. $238
e. $265

Item 51. Last summer Todd earned $205, Charlotte earned $562, and Dale earned $400. The average of their summer incomes was:

a. $1167.
b. $583.50. — teach. est.: 66%
c. $400. — stu. score: 44%
d. $389.

Item 52. A team scores two goals in each of its first five games and five goals in its sixth game. The average number of goals per game over the six games was:

a. 1 2/3
b. 2 1/6 — teach. est.: 53%
c. 2 1/2 — stu. score: 41%
d. 3
e. 3 1/2

Item 60. A can of gasoline holds nine liters. A larger can is exactly twice as long, twice as wide, and twice as high as the original can. That larger can will hold

a. 18 liters.
b. 36 liters.
c. 54 liters.
d. 72 liters.
e. 324 liters.

teach. est.: 35%
stu. score: 14%

Panel comments: Objective 56 was measured by ten items. As mentioned in Chapter 4, the student average score for the objective (55% correct) was not significantly different from the teacher mean estimate (61% correct).

Students scored higher on items 45 and 49 (average score 84% correct) than on the remaining eight items measuring objective 56. Were there any distinguishing characteristics? Panel discussion led to several observations which might be explored in the future. Item 49 was a one-step multiplication problem; item 45 required only simple addition and subtraction. Both items dealt with simple concepts, were relevent to everyday experience, could be solved in one or two steps and used only whole numbers or dollars and cents.

There were two observations about items 43 and 50. Item 50 required division, while item 43 required multiple steps. Twenty percent (20%) of the teachers reported that their students had received little or no exposure to these types of items.

Several observations and questions arose regarding the data on perimeter, percent, and average (items 42, 47, and 51). Eighty-seven percent (87%) of the teachers reported that their students had received adequate to heavy classroom exposure to the perimeter item. The question arose as to why so many students answered the item incorrectly if they had received adequate exposure to such material. Twenty-eight percent (28%) of the teachers reported that their students had received little or no exposure to percent problems like item 42. That data gave rise to several questions. Isn't percent an important part of everyday life? Shouldn't almost all eighth graders receive considerable exposure to percent? What do students know about percent? What should they know? What difficulties are they having? Item 46 was also related to percent, but the correct answer ($5) could have been obtained by subtracting 10% from 15%. Students could have obtained the correct answer for the wrong reasons.

Thirty percent (30%) of the teachers reported that their students had received little or no exposure to the concept "average." The question arose as to whether students shouldn't have some exposure by eighth grade.

Finally, the student score (14% correct) was considerably lower than the teacher estimate (35% correct) for item 60 which tested students on comparative capacities of different size containers. Several cautions are in order regarding interpretation of that result. The data related to only one item. Sixty-five percent (65%) of the teachers reported that their students had received little or no exposure to the material tested by the item. Capacity is a difficult concept to grasp. Comparisons among different capacities are far more difficult than comparisons of length or weight.

Discussion by the panel regarding the results for objective 56 suggested that as the items became more complex according to certain dimensions, the student scores became lower. Several dimensions were suggested as ones which might be investigated: concept difficulty, relevance to everyday life, types of numbers, complexity of process, and type of computation.

Chapter 3

Discussion of the Results

The mathematics panel was asked to study all data available from the Illinois Inventory of Educational Progress. The data included test results from 1976, 1978, and 1979; responses to teacher and principal surveys; and a survey of mathematics curricula. The panel was asked to give their overall reflections on the results of the 1979 eighth grade IIEP, taking into account the data and their experience in the field of mathematics education. The comments of this chapter are a distillation of the panel's reflections.

The test items on Topic II (Properties of Numbers) contain difficulties not usually noticed on a first reading. Nevertheless, the teacher survey indicated that the students had received considerable exposure to the topic, and student performance must be considered disappointing. More than half the students could not order decimals correctly, and three-fourths of the students could not order fractions correctly.

Student scores for Topic III (Numbers) and its subtopics were not significantly different from the teacher estimates. However, logical comparisons among the items and item results raised several questions. The items on whole numbers seemed conceptually and procedurally more difficult than other items. Yet, students did about as well on the whole number items as on other items. The items on decimals, fractions, and percent appeared to be easy, but from one-third to one-half of the students failed to obtain the correct answers. On one problem, 13% percent of the students added approximately \$3, \$5, \$9, and \$10 and came up with a sum of over two thousand dollars. Students must be impressed with the need to check their answers to make sure that they are reasonable and sensible. Although there was only one item on percent, it was conceptually easy. It was of real concern that almost half the students got it wrong. Eighth grade students should be able to change a percent to a decimal and do decimal multiplication.

A number of measurement items on metric units were tested in 1976, 1978, and 1979. Student scores were higher on each succeeding test. However, there is still room for improvement. All students should know basic measurement facts and relationships. Student ability to do problem solving in measurement was disappointing. The problems required computation skills to find the area of a room, the volume of a box, and the average speed of a vehicle. Less than half the students were able to solve these problems correctly.

Given the limited exposure of eighth grade students to algebra and geometry (as reported in the teacher survey), student performance was quite good. However, many students do not take basic algebra or geometry even in high school as indicated by The Illinois Census of Secondary School Course Offerings (1977)[1] conducted by the Illinois State Board of Education. Students who do not take algebra and geometry will find many opportunities for further education closed to them.

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[1] The Illinois Census of Secondary School Course Offerings. Springfield, Illinois 62777: Illinois State Board of Education, 1977.

The students were able to recall mathematics which they had learned and to do computations which were clearly indicated. However, for all topics, they were less able to apply previously acquired knowledge to new or unfamiliar situations. This inability is of particular concern since problem solving is required frequently in everyday life, as well as in further education. It is important for students to learn to visualize problems and work out correct solutions.

The 1979 Illinois Inventory of Educational Progress has provided some initial data about the mathematics achievement of eighth grade students in Illinois. The data have stimulated many questions. These questions can be utilized to develop hypotheses and gather data in the future in an attempt to learn more about student achievement and its possible improvement.

Chapter 4

Factor Analysis Results

The IIEP was first administered in 1976. Results from the test gave base line data regarding mathematics achievement. In 1978, the objectives were revised in terms that were more easily understood and more amenable to research on learning processes as they occur in students. Results were subjected to factor analysis, a statistical procedure which helps identify student abilities and strategies used in learning.

Factor analysis is a highly technical mathematical and statistical procedure which cannot be fully explained here. However, an intuitive understanding of factors and their derivation is possible. Fred Kerlinger, in his book Foundations of Behavioral Research (1973) wrote:

> Factor analysis is a method for determining the number and nature of the underlying variables among large numbers of measures.
>
> Generally speaking, if two tests measure the same thing, the scores obtained from them can be added together. If, on the other hand, the two tests do not measure the same thing, their scores cannot be added together. Factor analysis tells us, in effect, what tests or measures can be added and studied together rather than separately. It thus limits the variables with which the scientist must cope. It also (hopefully) helps the scientist to locate and identify unities or fundamental properties underlying tests and measures.
>
> A factor is a construct, a hypothetical entity that is assumed to underlie tests and test performance. A number of factors have been found to underlie intelligence, for example: verbal ability, numerical ability, abstract reasoning, spatial reasoning, and memory.

A HYPOTHETICAL EXAMPLE

Suppose we administer six tests to a large number of seventh grade pupils. We suspect that the six tests are not measuring six, but some smaller number of variables. The tests are: vocabulary, reading, synonyms, numbers, arithmetic (standardized tests), and arithmetic (teacher-made tests). The names of these tests indicate their nature. We label them respectively, V, R, S, N, AS, AT. (The last two tests, though both arithmetic, have different contents and reliabilities. We assume a good reason for including them both in a test battery.) After the tests are administered and scored, coefficients of correlation are computed between each test and every other test. We lay out the r's in a correlation matrix (usually called R matrix). The matrix is given in Table 37.1 (Table 15).

Table 15

TABLE 37.1 R MATRIX: COEFFICIENTS OF CORRELATION AMONG SIX TESTS

		V	*R*	*S*	*N*	*AS*	*AT*
Cluster I	*V*		.72	.63	.09	.09	.00
	R	.72		.57	.15	.16	.09
	S	.63	.57		.14	.15	.09
	N	.09	.15	.14		.57	.63
	AS	.09	.16	.15	.57		.72
	AT	.00	.09	.09	.63	.72	

Cluster II

...How many underlying variables or factors are there?...The factors are presumed to be underlying unities between the test performances. They are reflected in the correlation coefficients. If two or more tests are substantially correlated, then the tests share variance. They have common factor variance. They are measuring something in common.

...There are two factors. This is indicated by the clusters of r's circled and labeled I and II in Table 37.1. Note that V correlates with R,.72; V with S,.63; and R with S,.57. V, R, and S appear to be measuring something in common. It is important to note, however, that the tests in Cluster I, though themselves intercorrelated, are not to any great extent correlated with the tests in Cluster II. Likewise, N, AS, and AT, though themselves intercorrelated, are not substantially correlated with the tests V, R, and S. What is measured in common by the tests in Cluster I is evidently not the same as what is measured in common by the tests in Cluster II. There appear to be two clusters or factors in the matrix. (pp. 659-661).[2]

For further discussion of factor analysis, see Kerlinger (1973) pp. 659-692 and cited references.

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[2] Fred N. Kerlinger. Foundations of Behavioral Research (Second Edition). New York: Holt, Rinehart, and Winston, Inc., 1973.

Inferential Results of the IIEP

The first hypothesis stated that there would be three ability factors. The second hypothesis stated that there would be five topic factors. The data showed two ability factors and no topic factors.

Factor I

The abilities of recognition and computation both loaded on the first factor. Comparisons among the items indicated that the items were measuring learned material about which students usually receive instruction, practice, and guidance. Hypothesis 3 stated that teacher estimates would be higher than the student scores, which turned out to be the case for Factor I. Table 16 shows the results.

Table 16

Factor I: Learned Material

Objective	Item	Teacher Estimate	Student Performance
5	27	70%	51%
	28	67%	41%
	34	67%	62%
	35	66%	56%
10	25	75%	63%
	38	69%	73%
	39	63%	55%
14	32	67%	51%
	33	82%	77%
18	24	87%	85%
	26	67%	56%
42	40	50%	49%
	41	53%	50%
Mean		.68	.59
Standard Deviation		.10	.13
N		13	13

$t = 1.98^*$ $df = 24$

*significant $p < .05$

Factor II

Factor II was comprised of items which appeared to measure problem-solving ability in mathematics. The items required students to determine the nature of the problem and the processes needed to solve it. The ability required more than simple recall and application of learned steps. The hypothesis that teacher estimates would be higher than student scores was not supported. The estimates were higher, but the difference was not statistically significant. Table 17 shows the results.

Table 17

Factor II: Problem Solving

Objective	Item	Teacher Estimate	Student Performance
6	31	66%	25%
28	48	62%	51%
32	44	58%	51%
56	42	56%	43%
	43	60%	60%
	45	72%	81%
	46	58%	62%
	47	70%	52%
	49	76%	86%
	50	69%	65%
	51	66%	44%
	52	53%	41%
	60	35%	14%
Mean		.62	.51
Standard Deviation		.10	.20
N		13	13

t = 1.55 df = 24

+N.S.

Results for Specific Objectives

The eighth grade IIEP measured five objectives, i.e., objectives containing 3 or more items. The hypothesis stated that teacher estimates would be higher than student scores. Although the teacher estimates were higher than student scores for all objectives, the difference was statistically significant for objective 5 only. Table 18 shows the results.

Table 18

Mean Teacher Estimates and Student Scores
for Specific Objectives

Factor	Objective	Teacher Estimates Mean	S.D	N	Student Scores Mean	S.D.	N	T-test Results	df
I	5	68%	.02	4	52%	.01	4	3.42*	6
I	10	69%	.06	3	64%	.09	3	.855+	4
II	56	61%	.11	10	55%	.21	10	.820+	18
Not Loading on a Factor	37	74%	.08	4	73%	.09	4	.168+	6
Not Loading on a Factor	40	55%	.07	3	45%	.21	3	.775+	4

* significant $p < .01$
+ N.S.

APPENDIX A

INDEX OF MATHEMATICS OBJECTIVES FOR THE 1979 EIGHTH GRADE IIEP

Objective	Item	Page
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5	35	7
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14	33	10
18	24	11
18	26	11
22	29	12
26	36	13
26	37	13
28	48	13
29	30	15
32	44	15
37	53	17
37	54	17
37	55	17
37	62	17
38	56	18
38	57	18
40	58	18
40	59	18
40	65	19
42	40	20
42	41	20
45	63	21
45	64	21
48	66	21
54	23	22
56	42	24
56	43	24
56	45	23
56	46	23
56	47	24
56	49	23
56	50	23
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56	52	24
56	60	25

APPENDIX B

INDEX OF MATHEMATICS ITEMS FOR THE 1979 EIGHTH GRADE MATHEMATICS IIEP

Item	Objective	Page
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24	25	11
25	10	9
26	18	11
27	5	7
28	5	7
29	22	12
30	29	15
31	6	8
32	14	10
33	14	10
34	5	7
35	5	7
36	26	13
37	26	13
38	10	9
39	10	9
40	42	20
41	42	20
42	56	24
43	56	24
44	32	15
45	56	23
46	56	23
47	56	24
48	28	13
49	56	23
50	56	23
51	56	24
52	56	24
53	37	17
54	37	17
55	37	17
56	38	18
57	38	18
58	40	18
59	40	18
60	56	25
61	3	6
62	37	17
63	45	21
64	45	21
65	40	19
66	48	21

APPENDIX C

STATE BOARD OF EDUCATION
ILLINOIS OFFICE OF EDUCATION
Program Evaluation and Assessment Section
100 North First Street
Springfield, Illinois 62777

(1) (2) (3) (4)

8th GRADE MATH ATTENDANCE CENTER TEACHER SURVEY

INSTRUCTIONS: Starting with Column 8, indicate your response by placing a number corresponding to your opinion in the appropriate box. Return the form to your building principal when completed.

ITEM NUMBER (5-7)	WHEN WERE STUDENTS EXPOSED TO THE SUBJECT MATTER? 1. Exposed prior to this grade level. 2. Exposed this year. 3. Have not been exposed (8)	TO WHAT DEGREE HAVE STUDENTS BEEN EXPOSED TO THE SUBJECT MATTER? 1 Heavily 2. Adequately 3. Minimally (9)	HOW IMPORTANT IS MASTERY OF THIS SKILL? 1 Very Important 2 Important 3 Not Important (10)	DOES THE EXERCISE MEASURE SUBJECT MATTER? 1 Yes 2. No (11)	EXERCISE DIFFICULTY INDEX: 1 Too Easy 2 Appropriate Level of Difficulty 3 Too Difficult (12)	WHAT PERCENTAGE OF STUDENTS WILL ANSWER THIS ITEM CORRECTLY? (13-15)
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46						

ITEM NUMBER (5-7)	WHEN WERE STUDENTS EXPOSED TO THE SUBJECT MATTER? 1 Exposed prior to this grade level. 2 Exposed this year. 3 Have not been exposed (8)	TO WHAT DEGREE HAVE STUDENTS BEEN EXPOSED TO THE SUBJECT MATTER? 1 Heavily 2 Adequately 3 Minimally (9)	HOW IMPORTANT IS MASTERY OF THIS SKILL? 1 Very Important 2 Important 3 Not Important (10)	DOES THE EXERCISE MEASURE SUBJECT MATTER? 1 Yes 2. No (11)	EXERCISE DIFFICULTY INDEX: 1 Too Easy 2 Appropriate Level of Difficulty 3 Too Difficult (12)	WHAT PERCENTAGE OF STUDENTS WILL ANSWER THIS ITEM CORRECTLY? (13-15)
47						
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APPENDIX D

LIST OF MATHEMATICS PANEL

BUSINESS ADDRESS

Mr. Willie D. Anderson
Carbondale Community High School
Carbondale, Illinois

Mrs. Janet Barnard
Parkside Jr. High School
Normal, Illinois

Mrs. Marie Jernigan
Bureau of Mathematics
Chicago Board of Education
Chicago, Illinois

Mr. Wendell Meeks
Educational Consultant
Program, Planning, and Development Section
Illinois State Board of Education

Mrs. Betty F. Schuerman
Springfield District 186
Springfield, Illinois

Dr. Aurum I. Weinzweig
University of Illinois-Chicago Circle
Chicago, Illinois

Dr. Margariete Montague Wheeler
Northern Illinois University
DeKalb, Illinois
Department of Mathematical Science

Dr. Mervin M. Brennan
Department of Planning, Research, and Evaluation
Illinois State Board of Education

APPENDIX E

LIST OF PUBLICATIONS DESCRIBING THE RESULTS OF THE 1979 IIEP

1979 Illinois Inventory of Educational Progress Annual Report

Fourth Grade Mathematics Results of the 1979 Illinois Inventory of Educational Progress

Eighth Grade Mathematics Results of the 1979 Illinois Inventory of Educational Progress

Eleventh Grade Mathematics Results of the 1979 Illinois Inventory of Educational Progress

Energy Results of the Fourth, Eighth, and Eleventh Grade Illinois Inventory of Educational Progress

JAS/1413f